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## Resource price turbulence and macroeconomic adjustment for a resource exporter: a conceptual framework for policy analysis

### Abstract

The increased demand for energy and other resources in global markets, particularly arising from the rapidly developing economies of China and India, has resulted in considerable turbulence in resource prices, and most obviously that of oil. The recent magnitude of change, both positive and negative, in resource prices and their macroeconomic implications is of considerable contemporary importance for both resource importing and exporting economies. For a resource exporting economy, such as that of Australia, the resource price boom had a number of beneficial effects: increased government taxation revenues, increased employment and higher wages in the resource and resource related sectors, increased spending in the domestic economy and buoyant economic growth, increased resource exports to the booming economies of China and India and a stronger domestic currency with beneficial effects upon inflation. On the other hand these developments are likely to have adverse effects on the nonresource sector that is subject to more competition for limited resources, a stronger exchange rate results in a loss of international competitiveness and reduced exports, a loss of employment in the nonresource sector which is likely to be more labour intensive, and an eventual slow down in the overall economy. These positive and negative effects, and the overall impact of a resource price boom, will fundamentally require closer analysis of the structure of the economy under scrutiny. In this context the policy response by government is likely to be crucial in producing overall positive effects. The objective of this paper is to provide an analytical framework that can be utilised for a resource exporting economy for this purpose.

### Keywords

Resource, price, turbulence, macroeconomic, adjustment, for, resource, exporter, conceptual, framework, for, policy, analysis

### Disciplines

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# **Resource Price Turbulence and Macroeconomic Adjustment for a Resource Exporter: a conceptual framework for policy analysis**

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## **Abstract**

The increased demand for energy and other resources in global markets, particularly arising from the rapidly developing economies of China and India, has resulted in considerable turbulence in resource prices, and most obviously that of oil. The recent magnitude of change, both positive and negative, in resource prices and their macroeconomic implications is of considerable contemporary importance for both resource importing and exporting economies. For a resource exporting economy, such as that of Australia, the resource price boom had a number of beneficial effects: increased government taxation revenues, increased employment and higher wages in the resource and resource related sectors, increased spending in the domestic economy and buoyant economic growth, increased resource exports to the booming economies of China and India and a stronger domestic currency with beneficial effects upon inflation. On the other hand these developments are likely to have adverse effects on the non resource sector that is subject to more competition for limited resources, a stronger exchange rate results in a loss of international competitiveness and reduced exports, a loss of employment in the non resource sector which is likely to be more labour intensive, and an eventual slow down in the overall economy. These positive and negative effects, and the overall impact of a resource price boom, will fundamentally require closer analysis of the structure of the economy under scrutiny. In this context the policy response by government is likely to be crucial in producing overall positive effects. The objective of this paper is to provide an analytical framework that can be utilised for a resource exporting economy for this purpose.

This paper develops a dynamic macroeconomic model for a resource producing and exporting economy, with the objective of capturing key macroeconomic outcomes arising from an increase in the price of the resource. The adjustment process in the model emphasises a spending (or wealth) effect, an income effect, a revenue effect, a current account effect and an exchange rate effect from resource production that will facilitate a robust analysis of the macroeconomic impact of resource price shocks and policy responses to this.

**Key words:** Resource price shock, dynamic macroeconomic model, simulation analysis, macroeconomic adjustment, policy analysis.

**JEL classification:** E27, E60, E62, Q46, Q48.

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## 1. Introduction

The increased demand for energy and other resources in global markets, particularly arising from the rapidly developing economies of China and India, has resulted in considerable turbulence in resource prices, and most obviously for that of oil. Given the recent magnitude of change in resource prices, the macroeconomic implications of this for resource producing and exporting economies and resource importing economies is now of considerable contemporary importance. For a resource exporting economy, such as Australia, the resource price boom has had a number of beneficial effects, including increased government taxation revenues, increased employment and higher wages in the resource and resource related sectors, increased spending in the domestic economy and buoyant economic growth, increased resource exports to the booming economies of China and India and a stronger domestic currency resulting in beneficial effects for inflation. On the other hand these developments are likely to have adverse effects on the non resource sector that is subject to more competition for limited resources, a stronger exchange rate results in a loss of international competitiveness and reduced exports, a loss of employment in the non resource sector which is likely to be more labour intensive and an eventual slow down in the overall economy. These positive and negative effects, and the overall impact of a resource price boom, will fundamentally require closer analysis of the structure of the economy under scrutiny. In this context the policy response by government is likely to be crucial in producing overall positive welfare effects.

This paper develops a dynamic macroeconomic model for a resource producing and exporting economy, with the objective of capturing key macroeconomic outcomes arising from an increase in the price of the resource. The adjustment process in the model emphasises a spending (or wealth) effect, an income effect, a revenue effect, a current account effect and an exchange rate effect from resource production that will facilitate a robust analysis of the macroeconomic impact of resource price shocks and policy responses to this.

The paper proceeds as follows. Section 2 outlines the conceptual framework to be utilised. Section 3 presents the results of some simple simulations arising from a resource price shock and different policy response to this with the objective of improving macroeconomic outcomes for key variables. Finally, section 4 presents a summary of the major conclusions of this paper as well as some discussion of the results.

## 2. Literature review and conceptual framework

During the 1970s and the 1980s there was considerable literature on the so called 'Dutch disease', whereby, based upon the experience of the Dutch economy, the anticipated benefits arising from the production of a natural resource, in this case natural gas, had adverse effects on the non resource sector. Possible reasons for this behaviour have been variously explained in terms of a **resource movement effect** (Corden, 1984, Corden and Neary, 1982), a **spending or wealth effect**, a **revenue effect**, a **current account effect** and, finally, an **exchange rate effect** (see, for example, Buiter and Purvis, 1982; Eastwood and Venables, 1982; Harvie, 1989; and Neary and van Wijnbergen, 1984). During the period of the 1990s a number of contributions extended this literature by focusing upon endogenous capital stock accumulation as an additional wealth effect, considering the implications for adjustment arising from different exchange rate regimes (fixed or flexible) and the identification of optimal policy responses in a dynamic context with the objective of

minimising the adverse effects of a resource boom on the non resource sector (see Harvie, and Verrucci, 1991; Harvie, 1991; Harvie and Maleka, 1992; Harvie, 1992a; Harvie, 1992b; Harvie, 1992c; Harvie and Gower, 1993; Harvie, 1993; Harvie and Tran Van Hoa, 1994a; Harvie and Tran Van Hoa, 1994; Harvie and Thaha, 1994). Given the recent turbulence in oil and resource prices it is opportune to revisit this issue.

In this paper a dynamic macroeconomic model is developed to analyse the macroeconomic effects arising from an unanticipated hike in resource prices and competing policy responses to this, where the focus is placed upon modelling the macroeconomic outcomes for a resource producing and exporting economy. The basic model is summarised in Table 1, and is based upon the earlier contributions of Buiter and Purvis (1982), Harvie (1993) and Harvie and Thaha (1994), and contains a number of important underlying assumptions that are briefly discussed below.

Economic agents possess rational expectations. Non-financial markets do not clear continuously, as they are subject to sticky price and quantity adjustment. This latter assumption can be justified on the existence of adjustment costs and wage-price contracts. On the other hand, financial markets clear continuously, implying that financial variables can make discontinuous jumps to ensure financial market equilibrium<sup>1</sup>. Hence, the effect of any shock is transmitted initially through financial markets, and then to product and labour markets.

There are four financial assets available in the economy – domestic money, domestic bonds, foreign bonds and equities. The latter represent claims to the ownership of the physical capital stock used in the non-resource sector. The three non-money assets are perfect substitutes; however, for simplicity, only domestic bonds, money and equities are held by domestic residents. Domestic bonds are outside bonds, issued by the government and held by the private sector, and constitute part of private sector wealth. Continuous, and instantaneous, arbitrage results in the same expected instantaneous return on each non-money financial asset.

Domestic private sector wealth plays an important role in the model, through its effect on the demand for both financial assets and non-resource output. It consists of the domestic currency value of foreign assets stocks held, the value of the physical capital stock privately owned, real money balances, real bond balances and the permanent value of resources.

The model emphasises the long run nature of the adjustment process. The link between the short and long run arises from capital stock accumulation in the non-resource sector, foreign asset stock accumulation via developments in the current account and budgetary financing requirements. In long run steady state capital stock accumulation must cease and the current account and fiscal budget must be in balance. Emphasis on the long run is important in the context of a model that assumes economic agents possess rational expectations. Such models are characterised by a stable saddlepath property<sup>2</sup>, suggesting that long run equilibrium is only achievable if the economy adjusts immediately on to the appropriate saddlepath. An accurate

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<sup>1</sup> The assumption of rational expectations, combined with non-continual equilibrium in non financial markets but continual equilibrium in financial markets, was most famously advanced by Dornbusch (1976).

<sup>2</sup> See, for example, Dornbusch (1976).

identification of the long run steady state is, therefore, crucial to capture accurately the adjustment process during the short and medium run periods.

The model emphasises both the demand and supply of non-resource output. The long run nature of the model indicates that non-resource output supply is not fixed (at some natural level), but can vary with capital stock accumulation/de-cumulation in the non-resource sector. Developments in the supply of non-resource output represents a change in potential output supply in this sector.

The economy is assumed to be a major **resource producer** and **net resource exporter**. Net resource exports are endogenously determined, dependent upon both the production of the resource itself and the domestic demand for it. The difference between these is assumed to be fully exported. No attempt is made, however, to model the production of the resource itself<sup>3</sup>. It should also be emphasised that the economy under scrutiny is an exporter of a non-resource good. This non-resource good can be either consumed domestically or exported.

Finally, resource production affects this economy through five distinct channels, these being an **income effect** (arising from the production of the resource itself), a **revenue effect** (arising from revenue generated by the government from the production of the resource), a **spending effect** (arising from current income and future income (**wealth**) from the production of the resource), a **current account effect** (the resource production generates an increase in exports and enhances the current account) and finally an **exchange rate effect** (resource exports generate a stronger value of the domestic currency).

Thus, the essential features of the model are as outlined above. The specific system of equations that govern the model are now briefly outlined and discussed under the headings of product market, assets market, aggregate supply and the wage/price nexus, overseas sector and definitions (see Table 1). All of the variables are in log form, with the exception of the domestic and world nominal interest rates. A summary of the variables is provided in Table 2.

In the context of the product market, Equation (1) identifies the total demand for non-resource output, consisting of private consumption and investment spending, government spending and the trade balance. Equation (2) shows that private consumption spending depends upon non-resource output supply and private sector wealth. Private investment spending, Equations (3) and (4), is determined by Tobin's  $q$  ratio (Tobin, 1969). Government consumption expenditure, Equation (5), is assumed to be exogenous. Equations (6) and (7) show that government investment spending depends upon that required to attain policy-determined levels of public capital stock relative to the actual public capital stock. Equation (8) shows that total government spending consists of consumption and investment spending and social welfare spending. The budgetary stance, and its funding, is given by Equation (9). Fiscal deficits are financed through monetary accommodation as well as through sales of government liabilities (bonds). Tax revenue is sourced from two areas, non-resource production and resource production (Equation (10)). The non-resource trade balance is given by Equation (11), and depends upon the real exchange rate, domestic real income and world real income. Equations (12) and (13) show the real and permanent income definitions used in the model, and first used by Buiter and Purvis (1982) (see also Harvie 1993, 1994).

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<sup>3</sup> Such an attempt, however, would represent an interesting extension to the model.

**Table 1: Resource exporter model**

**Product Market**

$$No^d = \alpha_1 c^p + \alpha_2 i^p + \alpha_3 g + \alpha_4 T, \quad (1)$$

$$c^p = c_1 No^s + c_2 w^p, \quad (2)$$

$$i^p = \eta q, \quad (3)$$

$$\dot{k}^p = \eta q, \quad (4)$$

$$c^g = \bar{c}^g, \quad (5)$$

$$i^g = \varphi(k^{g*} - k^g), \quad (6)$$

$$\dot{k}^g = \varphi(k^{g*} - k^g), \quad (7)$$

$$g = \beta_1 c^g - \beta_2 No^s + \beta_3 i^g, \quad (8)$$

$$g - t^x = \chi_1(\dot{m} - \dot{p}) + \chi_2(\dot{b} - \dot{p}), \quad (9)$$

$$t^x = \gamma No^s + (1 - \gamma)(o^a + pres + e - p), \quad (10)$$

$$T = \lambda_1(e + p^* - p) - \lambda_2 y + \lambda_3 y^*, \quad (11)$$

$$y = \nu No^s + (1 - \nu)o^a + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*, \quad (12)$$

$$y^p = \nu No^{s^p} + (1 - \nu)o^p + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*, \quad (13)$$

**Asset markets**

$$m - p = \sigma_1 y - \sigma_2 r, \quad (14)$$

$$R = \theta_1 No^s - \theta_2 k^p + \theta_3 k^g, \quad (15)$$

$$\dot{q} = \delta_3^{-1}[q - \delta_1 R + \delta_2(r - \dot{m})], \quad (16)$$

$$w^p = \Omega_1(f + e - p) + \Omega_2(k^p + q) + \Omega_3(m - p) + \Omega_4(b - p) + \Omega_5 y^p, \quad (17)$$

$$\dot{m} = \zeta(\bar{m} - m), \quad (18)$$

**Aggregate supply and wage/price nexus**

$$p = \mu_1 w + \mu_2(e + pres) + (1 - \mu_1 - \mu_2)(e + p^*), \quad (19)$$

$$\dot{w} = \psi_1(No^d - No^s) + \psi_2 \dot{m}, \quad (20)$$

$$No^s = \phi_1 k^p + \phi_2 k^g - \phi_3(w - p), \quad (21)$$

**Overseas sector**

$$\dot{f} = \varepsilon_1 T + \varepsilon_2 r^* f + \varepsilon_3(o^{ne} + pres) - (1 - \varepsilon_2 - \varepsilon_3)(e - p), \quad (22)$$

$$o^{ne} = \tau(o^a - y), \quad (23)$$

**Definitions**

$$e = e - w, \quad (24)$$

$$l = m - w, \quad (25)$$

$$B = b - w, \quad (26)$$

$$\dot{e} = r - r^*. \quad (27)$$

<b>Table 2: Explanation of Model Variables</b>
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### Endogenous Variables

$No^d$	Aggregate demand for non-resource output
$c^p$	Private consumption
$i^p$	Private investment
$g$	Total government expenditure
$T$	Trade balance
$No^s$	Aggregate supply of non-resource output
$w^p$	Real private sector wealth
$k^p$	Private capital stock
$q$	Tobin's q
$c^g$	Government consumption spending
$i^g$	Government investment spending
$k^g$	Actual public capital stock
$t^x$	Total tax revenues
$m$	Nominal money supply
$p$	Domestic price level
$b$	Nominal domestic bonds
$e$	Nominal exchange rate
$y$	Real income
$w$	Domestic nominal wage
$y^p$	Permanent real income
$r$	Domestic nominal interest rate
$R$	Real profit
$f$	Foreign asset stocks
$o^{ne}$	Net resource exports
$c$	Real exchange rate
$l$	Real money balances
$B$	Real domestic bonds

### Exogenous variables

$\bar{c}^g$	Desired government consumption expenditure
$k^{g*}$	Desired public capital stock
$o^a$	Resource production
$pres$	Resource price
$p^*$	World price level
$y^*$	World real income
$No^{sp}$	Permanent non-resource income
$o^p$	Permanent resource income
$\bar{m}$	Policy determined money stock
$r^*$	World nominal interest rate



Equations (14-18) define asset market equilibrium. Four financial assets should be addressed here, namely domestic money, domestic bonds, foreign bonds, and equities which determine the  $q$  ratio. Financial assets, denominated in domestic or foreign currency are perfect substitutes, where arbitrage between them results instantaneously in the same expected rate of return. Equation (14) gives the conventional money market equilibrium, where the demand for real money balances depends upon real income and the nominal interest rate. Equation (15) shows that the real return on private capital used in the non-resource sector depends positively on the level of real non-resource production (as measured by output supply), negatively on the stock of private capital due to diminishing marginal returns, and positively on the stock of public capital. The latter holds true since public and private capital are assumed complementary in nature. The productivity of private capital rises as the government provides more public investment, such as in the form of infrastructure (Aschauer, 1989a, 1989b). Equation (16) identifies the change in Tobin's  $q$  ratio. It is derived from the arbitrage condition on equating the returns on domestic and foreign bonds and equities. Equation (17) describes private sector wealth, which depends positively on: the real domestic currency value of domestically held foreign assets; the value of private capital stock; real money balances; real bond holdings and resource wealth. Equation (18) shows the money growth equation, which is the difference between the policy targeted money supply and the current money supply.

The wage-price nexus and aggregate non-resource output supply are given by Equations (19-21). Equation (19) indicates that the domestic price level is a weighted average of the domestic nominal wage cost, the domestic cost of the resource good and the domestic cost of the world non-resource imported good. Equation (20) indicates that nominal wages adjust in line with a simple inflation expectations augmented Phillips curve. Equation (21) shows that aggregate non-resource output supply, derived from a simple production function relationship, depends positively on the private capital stock, public capital stock, and negatively on the real wage rate.

The overseas sector consists of Equations (22) and (23). Equation (22) shows that the current account of the balance of payments, which is equivalent to the change in domestic holdings of foreign assets, depends positively on the trade balance, foreign interest income, net resource exports and negatively on the real exchange rate. In long run steady state the current account balance must be zero, otherwise further wealth effects will occur which in turn implies further macroeconomic adjustment. Equation (23) shows that net resource exports depend positively upon the actual production of the resource and negatively upon real income. Higher domestic real income will result in greater domestic demand for the resource, and, hence, less is available for export at any level of resource production.

Equations (24-27) contain definitions used in the model. Equation (24) defines the real exchange rate, Equation (25) defines real money balances, and Equation (26) defines real bond balances, while Equation (27) defines the uncovered interest parity condition. Exchange rate expectations depend upon the difference between the domestic and world nominal interest rates.

### **Dynamic stability property of the model**

The model is characterised by a stable saddlepath property in which long run equilibrium is only achievable if the economy is on the relevant stable saddlepath. The model is characterised by having variables that are either predetermined (non-jump) or non predetermined (jump) variables. The system of equations (1) – (27) can

be reduced and rewritten as the system of equations given in Table 3, where the eliminated variables can be determined from the appropriate equations in the original system of equations once the solution for the other variables is known. In this case, there are eight differential variables in the model:  $k^p$ ,  $k^g$ ,  $m$ ,  $b$ ,  $w$ ,  $f$ ,  $q$  and  $e$ ; twelve algebraic variables:  $r$ ,  $No^d$ ,  $No^s$ ,  $T$ ,  $w^p$ ,  $y$ ,  $y^p$ ,  $R$ ,  $o^{pe}$ ,  $c$ ,  $l$  and  $B$ ; and ten exogenous variables that are used to derive a solution for the long run steady state:  $\bar{m}$ ,  $r^*$ ,  $k^{g*}$ ,  $o^a$ ,  $pres$ ,  $o^p$ ,  $No^{sp}$ ,  $\bar{c}^g$ ,  $p^*$  and  $y^*$ .

Of the eight differential variables, the first six are predetermined non-jump variables that adjust only gradually. The last two differential variables,  $q$  and  $e$ , are assumed to be non-predetermined or jump variables. For dynamic stability it is required that the system generates six negative eigenvalues and two positive eigenvalues. Given the complexity of the model, analytically unambiguous results cannot be obtained, so instead we obtain a calibrated solution of the steady state properties of the system as well as the dynamics of adjustment. In this paper the author's use a program called 'Saddlepoint'<sup>4</sup> to obtain the steady state solution of the model and to conduct numerical simulations of the model for exogenous shocks. The equations used in 'Saddlepoint' are based upon the equations of the model in Table 1, and are summarised in Table 3, where the relevant matrices to be solved are given in Table 4. Further, the matrices are compiled on the basis of the order of the relevant differential, algebraic and exogenous variables given in Table 3. In the following section, simulations of the model for a change in the price of the resource and different policy responses to this by government are conducted.

### 3. Resource price turbulence and policy response simulations

This section conducts two simulations arising from an increase in the price of the resource. Both cases assume that there is an immediate and permanent increase in the price of the resource by 10 per cent (the baseline case). We also then consider responses to these disturbances through different spending measures, focusing upon that of government consumption and capital expenditure, and then compare these outcomes to the baseline case. The results for these two cases are shown in Figures 1 and 2 respectively. Further, in order to illustrate both the short and long term behaviour of each variable presented in Figures 1 and 2, we provide simulations for not only the long term of 200 periods, but also over the short term of 30 periods. The parameters values used to obtain these simulation outcomes are summarised in Table 5.

#### *Case 1 A permanent increase in $pres$ – responding with $\bar{c}^g$ transiently*

In this sub-section three scenarios are considered:

1. "Riding the wind" (**the baseline case**) – in this case the increase in  $pres$  is not met with any policy response. The authorities simply accept the shock and hope everything works out OK.
2. "Going with the wind" – in line with the increase in  $pres$ , we increase  $\bar{c}^g$ , but transiently, where  $\bar{c}^g$  initially increases by 2.5 per cent, then another 2.5 per cent in the next period to give a total increase of 5 per cent above baseline.

<sup>4</sup> 'Saddlepoint' is an algorithm developed by Austin and Buitier (1982) to solve systems of linear differential equations with constant coefficients. It is based upon the solution provided by Blanchard and Khan (1980) for systems of linear difference equations. See also Blanchard (1981).

**Table 3: The Equations for Saddlepoint**

The 8 differential equations for Saddlepoint are:

$$0 = \frac{dk^p}{dt} - \eta q, \quad (29)$$

$$0 = \frac{dk^g}{dt} + \varphi k^g - \varphi k^{g*}, \quad (30)$$

$$0 = \mu_1(\chi_2 + \chi_1) \frac{dw}{dt} - (\chi_2 + \chi_1)(-1 + \mu_1) \frac{de}{dt} - \chi_2 \frac{db}{dt} - \chi_1 \frac{dm}{dt} - \beta_3 \varphi k^g + (1 - \gamma) \mu_1 w \\ - (1 - \gamma) \mu_1 e - (\gamma + \beta_2) N o^s + \beta_3 \varphi k^{g*} - (1 - \gamma) o^a + (1 - \gamma)(\mu_2 - 1) pres + \beta_1 \bar{c}^g \\ - (1 - \gamma)(-1 + \mu_1 + \mu_2) p^*, \quad (31)$$

$$0 = \frac{dq}{dt} + \frac{\delta_2}{\delta_3} \frac{dm}{dt} - \frac{q}{\delta_3} - \frac{\delta_2 r}{\delta_3} + \frac{\delta_1 R}{\delta_3}, \quad (32)$$

$$0 = \frac{dm}{dt} + \zeta m - \zeta \bar{m}, \quad (33)$$

$$0 = \frac{dw}{dt} - \psi_2 \frac{dm}{dt} - \psi_1 N o^d + \psi_1 N o^s, \quad (34)$$

$$0 = \frac{df}{dt} + (-1 + \varepsilon_2 + \varepsilon_3) \mu_1 w - \varepsilon_2 r^s f - (-1 + \varepsilon_2 + \varepsilon_3) \mu_1 e - \varepsilon_1 T - \varepsilon_3 o^{nc} \\ + [-\varepsilon_3 - \mu_2(1 - \varepsilon_2 - \varepsilon_3)] pres - (-1 + \varepsilon_2 + \varepsilon_3)(-1 + \mu_1 + \mu_2) p^*, \quad (35)$$

$$0 = \frac{de}{dt} - r + r^s. \quad (36)$$

The 12 algebraic equations for Saddlepoint are:

$$0 = N o^d + \alpha_3 \beta_3 \varphi k^g - \alpha_2 \eta q - (\alpha_1 c_1 - \alpha_3 \beta_2) N o^s - \alpha_4 T - \alpha_1 c_2 w^p - \alpha_3 \beta_3 \varphi k^{g*} - \alpha_3 \beta_1 \bar{c}^g, \quad (37)$$

$$0 = T + \lambda_1 \mu_1 w - \lambda_1 \mu_1 e + \lambda_2 y + \lambda_1 \mu_2 pres - \lambda_1(\mu_1 + \mu_2) p^* - \lambda_3 y^s, \quad (38)$$

$$0 = y + (\mu_1 - \nu) w - (\mu_1 - \nu) e - \nu N o^s + (\nu - 1) o^a + (\nu - 1 + \mu_2) pres + (1 - \mu_1 - \mu_2) p^*, \quad (39)$$

$$0 = y^p + (\mu_1 - \nu) w - (\mu_1 - \nu) e + (\nu - 1 + \mu_2) pres + (\nu - 1) o^p + (1 - \mu_1 - \mu_2) p^* - \nu N o^{s''}, \quad (40)$$

$$0 = \sigma_2 r - \sigma_1 y + m - \mu_1 w + (\mu_1 - 1) e - \mu_2 pres - (1 - \mu_1 - \mu_2) p^*, \quad (41)$$

$$0 = R - \theta_1 N o^s + \theta_2 k^p - \theta_3 k^g, \quad (42)$$

$$0 = w^p - \Omega_2 k^p - \Omega_3 m - \Omega_4 b + \mu_1(\Omega_1 + \Omega_3 + \Omega_4) w - \Omega_1 f - [\Omega_1 \mu_1 - (1 - \mu_1)(\Omega_3 + \Omega_4)] e \\ - \Omega_2 q - \Omega_3 y^p + \mu_2(\Omega_1 + \Omega_3 + \Omega_4) pres - (\Omega_1 + \Omega_3 + \Omega_4)(-1 + \mu_1 + \mu_2) p^*, \quad (43)$$

$$0 = N o^s - \phi_1 k^p - \phi_2 k^g + \phi_3(1 - \mu_1) w - \phi_3(1 - \mu_1) e - \phi_3 \mu_2 pres - \phi_3(1 - \mu_1 - \mu_2) p^*, \quad (44)$$

$$0 = o^{nc} + \tau y - \tau o^a, \quad (45)$$

$$0 = c - e + w, \quad (46)$$

$$0 = l - m + w, \quad (47)$$

$$0 = B - b + w. \quad (48)$$

**Table 4: Matrices for Saddlepoint**

The matrix equations are:

$$\begin{aligned} M_1 V_1 + M_2 V_2 + M_3 V_3 + M_4 V_4 &= 0, \\ M_5 V_1 + M_6 V_2 + M_7 V_3 + M_8 V_4 &= 0, \end{aligned}$$

where

$$M_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\eta & 0 \\ 0 & \varphi & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\beta_3 \varphi & 0 & 0 & (1-\gamma)\mu_1 & 0 & 0 & -(1-\gamma)\mu_1 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\delta_3^{-1} & 0 \\ 0 & 0 & \zeta & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_1(1-\varepsilon_2-\varepsilon_3) & -\varepsilon_2 r^* & 0 & \mu_1(1-\varepsilon_2-\varepsilon_3) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\chi_1 & -\chi_2 & \mu_1(\chi_1 + \chi_2) & 0 & 0 & (\chi_1 + \chi_2)(1-\mu_1) \\ 0 & 0 & \frac{\delta_2}{\delta_3} & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\psi_2 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$M_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\gamma - \beta_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\delta_2}{\delta_3} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\delta_1}{\delta_3} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\psi_1 & \psi_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\varepsilon_1 & 0 & 0 & 0 & 0 & -\varepsilon_3 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\varphi & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta_3 \varphi & -(1-\gamma) & (1-\gamma)(\mu_2-1) & 0 & 0 & \beta_1 & (1-\gamma)(1-\mu_1-\mu_2) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\zeta & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\varepsilon_3 - \mu_2(1-\varepsilon_2-\varepsilon_3) & 0 & 0 & 0 & -(1-\varepsilon_2-\varepsilon_3)(1-\mu_1-\mu_2) & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_5 = \begin{bmatrix} 0 & \alpha_3 \beta_3 \varphi & 0 & 0 & 0 & 0 & -\alpha_2 \eta & 0 \\ 0 & 0 & 0 & 0 & \lambda_1 \mu_1 & 0 & 0 & -\lambda_1 \mu_1 \\ 0 & 0 & 0 & 0 & \mu_1 - \nu & 0 & 0 & \nu - \mu_1 \\ 0 & 0 & 0 & 0 & \mu_1 - \nu & 0 & 0 & \nu - \mu_1 \\ 0 & 0 & 1 & 0 & -\mu_1 & 0 & 0 & \mu_1 - 1 \\ \theta_2 & -\theta_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\Omega_2 & 0 & -\Omega_3 & -\Omega_4 & \mu_1(\Omega_1 + \Omega_3 + \Omega_4) & -\Omega_1 & -\Omega_2 & -\Omega_1 \mu_1 + (1-\mu_1)(\Omega_3 + \Omega_4) \\ -\phi_1 & -\phi_2 & 0 & 0 & \phi_3(1-\mu_1) & 0 & 0 & \phi_3(\mu_1-1) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix},$$

$$M_6 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_7 = \begin{bmatrix} 0 & 1 & \alpha_3 \beta_2 - \alpha_1 c_1 & -\alpha_4 & -\alpha_1 c_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & \lambda_2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\nu & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ \sigma_2 & 0 & 0 & 0 & 0 & -\sigma_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\theta_1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & -\Omega_5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \tau & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$M_8 = \begin{bmatrix} 0 & 0 & -\alpha_3 \beta_3 \varphi & 0 & 0 & 0 & 0 & -\alpha_3 \beta_1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_1 \mu_2 & 0 & 0 & 0 & -\lambda_1 (\mu_1 + \mu_2) & -\lambda_3 & 0 & 0 \\ 0 & 0 & 0 & \nu - 1 & -1 + \nu + \mu_2 & 0 & 0 & 0 & 1 - \mu_1 - \mu_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 + \nu + \mu_2 & \nu - 1 & -\nu & 0 & 1 - \mu_1 - \mu_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_2 & 0 & 0 & 0 & -1 + \mu_1 + \mu_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \mu_2 (\Omega_1 + \Omega_3 + \Omega_4) & 0 & 0 & 0 & (\Omega_1 + \Omega_3 + \Omega_4) (1 - \mu_1 - \mu_2) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\phi_3 \mu_2 & 0 & 0 & 0 & -\phi_3 (1 - \mu_1 - \mu_2) & 0 & 0 & 0 \\ 0 & 0 & 0 & -\tau & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

and

$$V_1 = \begin{bmatrix} k^p \\ k^g \\ m \\ b \\ w \\ f \\ q \\ e \end{bmatrix}, \quad V_2 = \begin{bmatrix} \dot{k}^p \\ \dot{k}^g \\ \dot{m} \\ \dot{b} \\ \dot{w} \\ \dot{f} \\ \dot{q} \\ \dot{e} \end{bmatrix}, \quad V_3 = \begin{bmatrix} r \\ N_{O^d} \\ N_{O^s} \\ T \\ w^p \\ y \\ y^p \\ R \\ o^{ue} \\ c \\ l \\ B \end{bmatrix}, \quad V_4 = \begin{bmatrix} \dot{m} \\ r^* \\ k^{g^*} \\ o^a \\ pres \\ o^p \\ N_{O^{sp}} \\ \xi^g \\ p^* \\ y^* \end{bmatrix}.$$

**Table 5: Parameter values**

Parameter	Value assumed	Parameter	Value assumed	Parameter	Value assumed
$\alpha_1$	0.5	$\lambda_1$	0.5	$\sigma_1$	1.0
$\alpha_2$	0.1	$\lambda_2$	0.5	$\sigma_2$	0.5
$\alpha_3$	0.5	$\lambda_3$	0.5	$\mu_1$	0.7
$\alpha_4$	0.3	$\theta_1$	0.5	$\mu_2$	0.1
$c_1$	0.8	$\theta_2$	0.5	$\psi_1$	0.8
$c_2$	0.1	$\theta_3$	0.5	$\psi_2$	1.0
$\eta$	0.7	$\delta_1$	0.5	$\phi_1$	0.4
$\varphi$	0.2	$\delta_2$	0.5	$\phi_2$	0.4
$\beta_1$	0.5	$\delta_3$	0.5	$\phi_3$	0.4
$\beta_2$	0.2	$\Omega_1$	1.0	$\varepsilon_1$	1.0
$\beta_3$	0.3	$\Omega_2$	1.0	$\varepsilon_2$	1.0
$\chi_1$	0.5	$\Omega_3$	1.0	$\varepsilon_3$	1.0
$\chi_2$	0.5	$\Omega_4$	1.0	$\tau$	0.2
$\gamma$	0.8	$\Omega_5$	1.0	$r^*$	0.05
$\nu$	0.8	$\zeta$	0.5		

Then the response begins to be removed in increments of 2.5 per cent until zero is reached (back to the initial level).

3. “Going against the wind” – in opposition to the increase in *pres*, we decrease  $\bar{c}^g$ , but transiently, where  $\bar{c}^g$  initially decreases by 2.5 per cent, then another 2.5 per cent in the next period to give a total decrease of 5 per cent below baseline. Then the response begins to be removed in increments of 2.5 per cent until zero is reached (back to the initial level).

Specifically, the shock and response profiles for these three scenarios are summarised in Table 6.

**Table 6 Scenario profiles**

Period $n$		1	2	3	4	5	6 – 200
Shock		<i>pres</i>	0	10%	10%	10%	10%
Response	— — — — (+) $\bar{c}^g$	0	0	2.5%	5%	2.5%	0
	— (0) $\bar{c}^g$	0	0	0	0	0	0
	• • • • • (–) $\bar{c}^g$	0	0	–2.5%	–5%	–2.5%	0

Outcomes from each of these three scenarios, for selected macroeconomic variables, can be observed from Figure 1 and from Table 7. The need for brevity prevents discussion of all of these variables, instead focus is placed upon – the real exchange rate, private capital stock, non-resource demand and supply, the  $q$  ratio, the non-resource trade balance and real income.

A sizeable appreciation of the real exchange rate takes place in the short to medium run for the baseline scenario, and for the transient increase in government consumption scenario. The real exchange rate also appreciates initially for the reduction in government consumption spending scenario but this is quickly reversed. These real exchange rate appreciations result in a loss of competitiveness for non-resource exports, and, as can be observed from Figure 1, are driven primarily by an appreciation of the nominal exchange rate. Over the long-run, appreciation of the

real exchange rate in all three scenarios is about 7.2 per cent. Major volatility in the real and nominal exchange rates is apparent, particularly in the short to medium runs, with this being most apparent in scenario 3. Reference to summary Table 7 indicates that least volatility in the real exchange rate occurs in scenario 2, while scenario 3 produces the largest volatility. The baseline case is in between. Consequently, increasing government consumption expenditure can reduce the size of real and nominal exchange rate volatility. In addition, an increase in government consumption spending produces a lower average appreciation of the real exchange during the adjustment process (reduced loss of international competitiveness for the non-resource sector). Consequently, **increasing government consumption spending as a result of a resource price shock can improve outcomes for the real exchange rate in comparison to the baseline case.** The opposite is the case for a reduction in government consumption spending.

The private capital stock is also subject to volatility in all three scenarios, but again this is most apparent in the case of scenario 3 (see Table 7). The private capital stock is reduced in steady state under all three scenarios, by around 0.75 per cent, however the lowest average decline throughout the simulation period occurs in scenario 3. This is offset by the greater volatility of this variable for this same scenario. The least volatile case for this variable is scenario 2, where there is an increase in government consumption spending. However, this is offset by the greater average decline for this variable throughout the simulation period. The private capital stock is a key variable for economic growth. Consequently, how it evolves is important for the economy and government. **The government faces a tough decision, according to the results presented here, for the private capital stock in terms of reducing the degree of volatility of this variable or choosing a policy option that reduces its overall average percentage decline.**

Non-resource demand and supply are also subject to major volatility, and both are lower in the long run steady state for all scenarios by around 0.78 per cent. Most volatility occurs in scenario 3 while the lowest volatility occurs in scenario 2. The lowest average percentage decline for both of these variables during the adjustment process occurs for scenario 2. Hence, for **non-resource demand and supply, their volatility of adjustment and average percentage decline from base during the adjustment process can be improved relative to the baseline case by a policy emphasis of expanding government consumption spending.** The primary reason for the overall deterioration in non-resource demand is due to the overall deterioration in the non-resource trade balance for all three scenarios, which is strongly linked to the appreciation of the real exchange rate mentioned previously. Private investment expenditure remains largely stagnant, overall government expenditure increases slightly as does private consumption spending. Hence, severe external developments exert major downward pressure on non-resource demand. The deterioration in non-resource supply is driven by higher real wages, a lower private capital stock and flat public capital expenditure.

Adjustment of the major financial variables, the  $q$  ratio, nominal interest rate and real return on physical assets produces some interesting outcomes. In each of the three scenarios these financial variables all return to baseline in steady state. For each of these variables volatility is noticeably lower for scenario 2 (increased government consumption spending) but noticeably larger for scenario 3 (reduced government consumption spending) relative to the baseline scenario. The change in these variables during the adjustment process also indicates that scenario 2 can improve financial outcomes relative to the base case with the exception of the interest rate. This actually experiences an average percentage increase during the adjustment process, while the other two scenarios experience an average percentage decline in the interest rate during the adjustment process. According to these results, financial market volatility can in general be reduced as well as their average percentage change reduced through an expansionary government consumption spending policy. The major exception being the interest rate.

The non-resource trade balance is quite volatile, particularly so for the baseline case and scenario 3. The latter scenario produces a particularly volatile outcome. However, it is clear that an increase in government consumption spending can reduce the extent of volatility of this variable during the adjustment process. In all scenarios the non-resource trade balance deteriorates by around 3.6 per cent in steady state, but on average is lower throughout the adjustment process in scenario 3. Hence **an expansionary government consumption spending policy can improve non-resource trade balance outcomes (volatility and size of adjustment) relative to the baseline scenario.**

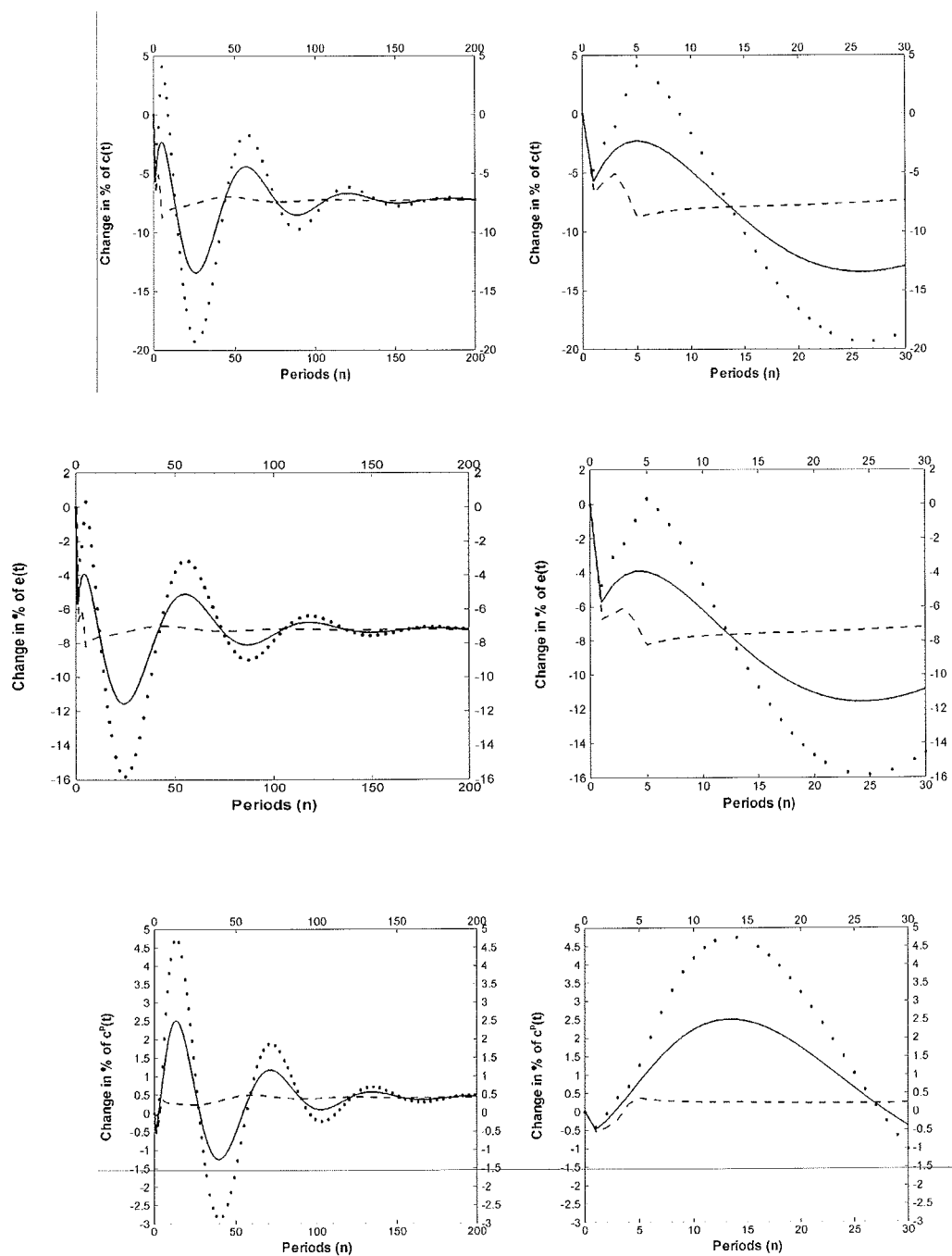
Finally, developments in real income are also quite illuminating for all three scenarios. Real income consists of both output produced in the resource and non-resource sectors. Volatility is noticeably larger in scenario 3 and lowest in scenario 2. Once again the baseline case is in the middle. For all three scenarios real income is 1.1 per cent higher in steady state, but the average increase in real income during the whole adjustment process is higher in scenario 3 but is prone to greater volatility. **For this variable there is no unambiguously better policy in terms of using government consumption spending.** An increase in spending reduces the volatility of adjustment but the average percentage increase during the adjustment process is less, and vice versa for the scenario where government consumption spending is reduced.

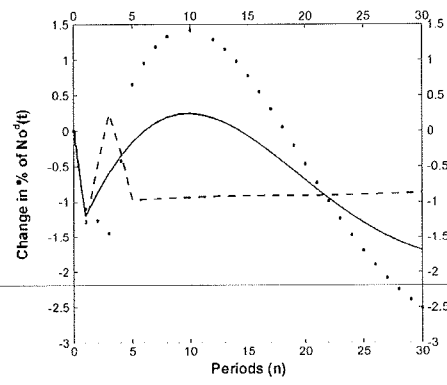
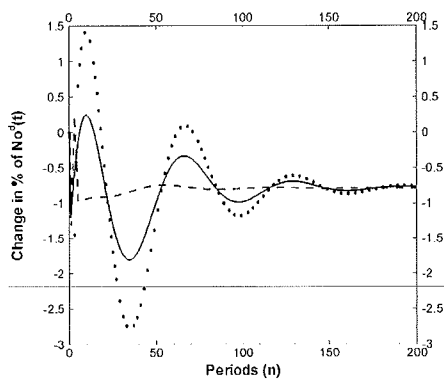
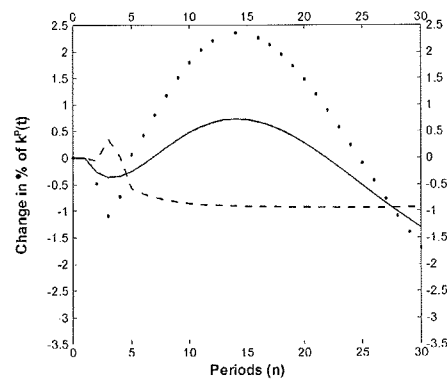
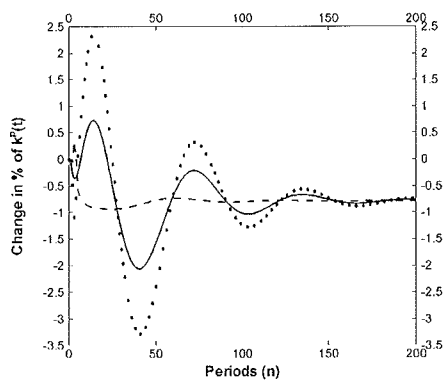
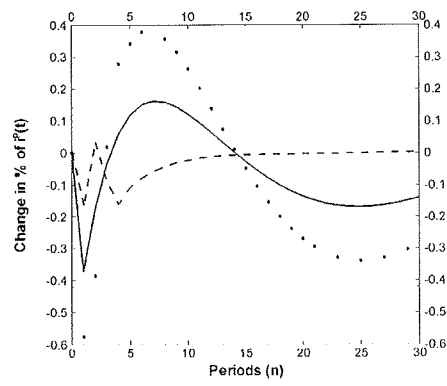
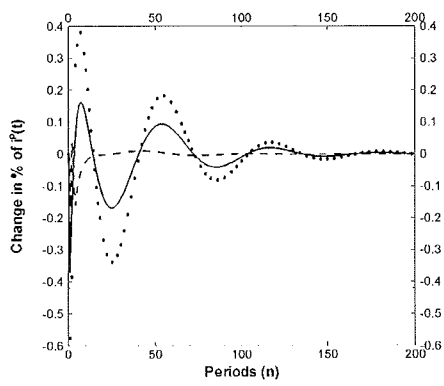
We can conclude from the simulation results presented in Figure 1 and Table 7 that the resource exporter benefits from a higher resource price in the following ways: an increase in real income, and this is the case for all three scenarios; an overall improvement in foreign asset stocks held but only for scenarios 1 and 3; and greater domestic private sector real wealth for all three scenarios. However, the higher resource price will appreciate the real exchange rate resulting in a loss of competitiveness for the non-resource sector, which in turn results in a deterioration of the non-resource trade balance and reduces non-resource output demand and supply. The non-resource sector is also adversely affected by a decline in private sector capital stock, a lower  $q$  ratio and reduced returns on capital. The nominal interest will be subjected to considerable volatility throughout. The government fiscal balance also deteriorates.

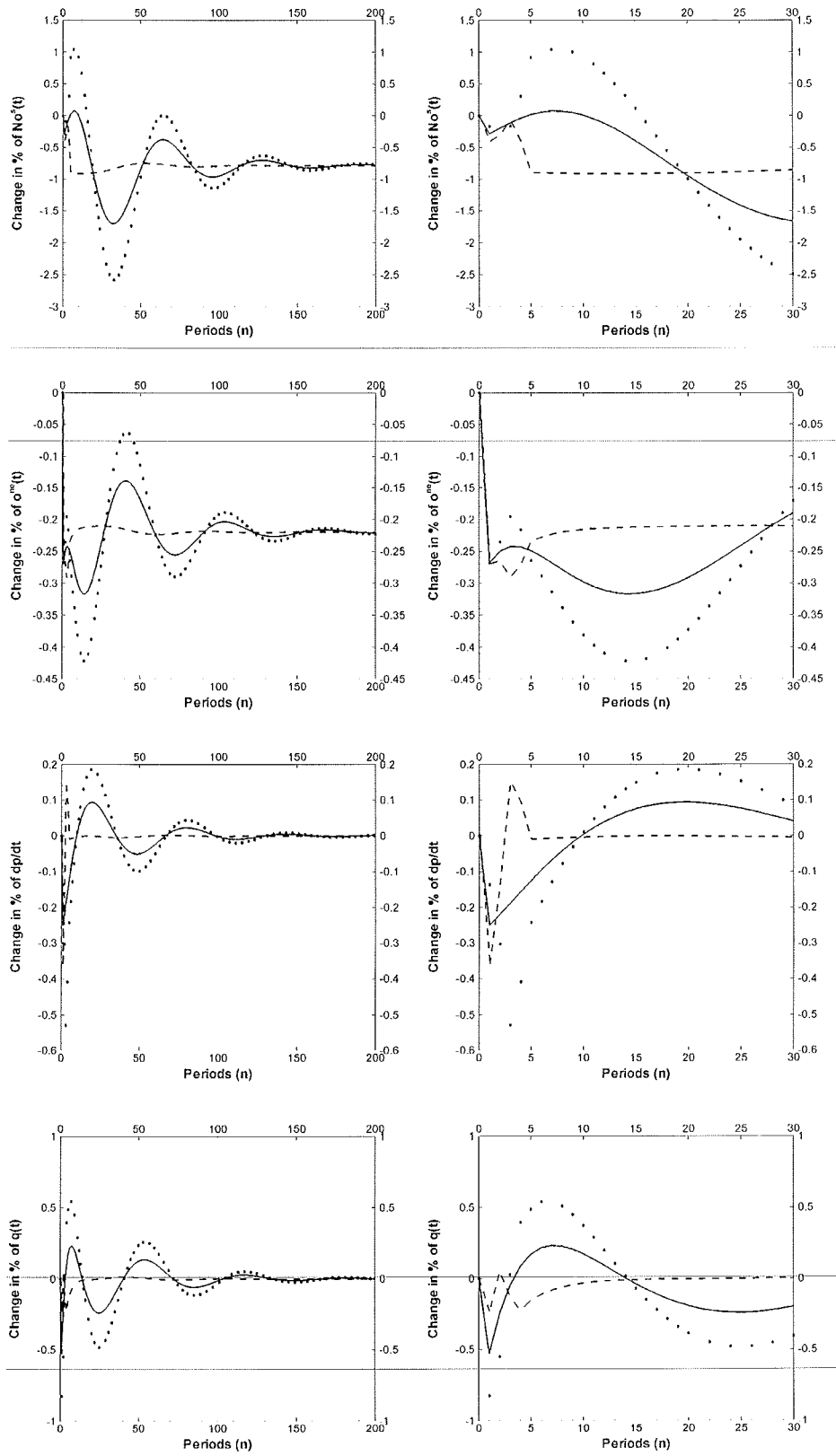
Deliberate policy action by government in response to the resource price shock can also improve outcomes, both in terms of improved average percentage change outcomes for key macroeconomic variables as well as their volatility during the adjustment process. For example, the extent of the appreciation of the real exchange and the volatility of its adjustment can be alleviated by increasing government consumption spending. The loss of non-resource output demand and supply as well as the volatility of their adjustment can also be alleviated by increasing government consumption spending, and this is also the case for the non-resource trade balance. On the other hand the accumulation of foreign asset stocks can be improved by reducing government consumption spending, but this can only be achieved by introducing greater volatility of adjustment of this variable. Consequently, from the results presented here, the authorities have the difficult task of deciding whether achieving improved overall outcomes for a key macroeconomic variable by a change in policy is worth the additional volatility of adjustment of that variable, and others, during the adjustment process.

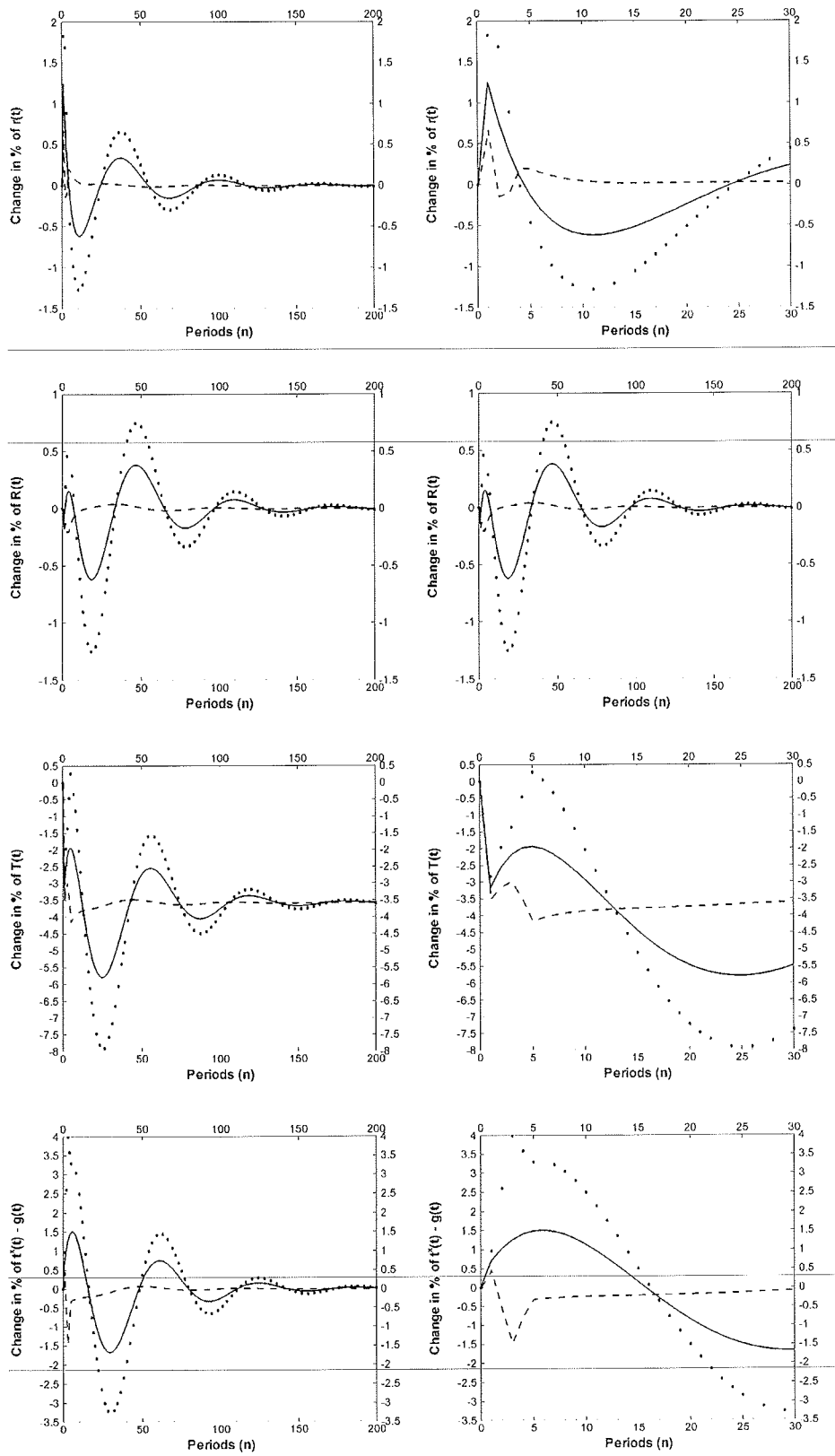


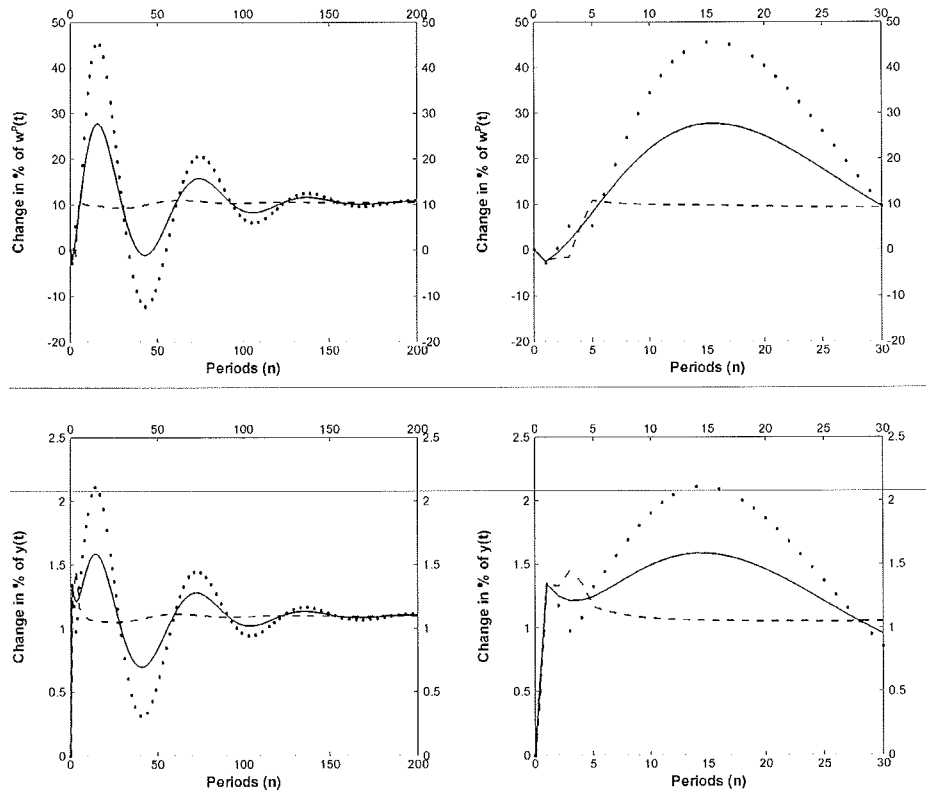
**Figure 1 Macroeconomic adjustment from a permanent and instantaneous 10 per cent increase in the price of the resource, and transient increases/decreases in government consumption spending**











*Case 2 A permanent increase in  $pres$  – responding with  $k^{g*}$  transiently*

In this sub-section three scenarios are considered:

1. “Riding the wind” (**the baseline case**) – in this case the increase in  $pres$  is not met with any policy response. The authorities simply accept the shock and hope everything works out OK.
2. “Going with the wind” – in line with the increase in  $pres$ , we increase  $k^{g*}$ , but transiently, where  $k^{g*}$  initially increases by 2.5 per cent, then another 2.5 per cent in the next period to give a total increase of 5 per cent above baseline. Then the response begins to be removed in increments of 2.5 per cent until zero is reached.
3. “Going against the wind” – in opposition to the increase in  $pres$ , we decrease  $k^{g*}$ , but transiently, where  $k^{g*}$  initially decreases by 2.5 per cent, then another 2.5 per cent in the next period to give a total decrease of 5 per cent below baseline. Then the response begins to be removed in increments of 2.5 per cent until zero is reached

Specifically, the shock and response profiles for these three scenarios are given in Table 8.

Table 7 Summary of outcomes from Case 1

	Positive Response					No Response					Negative Response							
	Area	Area	Av.	Final	Max	Min	Area	Area	Av.	Final	Max	Min	Area	Area	Av.	Final	Max	Min
$b(t)$	3040.720	3046.840	15.053	15.740	17.820	-1.926	2374.130	3509.470	11.753	15.420	36.900	-32.490	1707.540	4722.440	8.453	15.100	57.080	-78.100
$B(t)$	3022.350	3024.890	14.962	15.660	17.740	-1.235	2349.090	3491.630	11.629	15.350	36.890	-32.610	1675.840	4714.850	8.296	15.040	57.050	-78.080
$b(t) - p(t)$	3259.190	3259.890	16.135	16.840	18.870	-0.528	2595.840	3648.900	12.851	16.530	37.600	-30.680	1932.480	4814.850	9.567	16.220	57.380	-75.530
$c(t)$	-1454.980	1454.980	-7.203	-7.260	0.000	-8.775	-1488.020	1488.020	-7.366	-7.256	0.000	-13.430	-1521.040	1548.120	-7.530	-7.252	4.117	-19.360
$c^g(t)$	10.000	10.000	0.050	0.000	5.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-10.000	10.000	-0.050	0.000	0.000	-5.000
$c^p(t)$	77.670	80.248	0.385	0.428	0.500	-0.549	88.595	132.572	0.439	0.455	2.506	-1.256	99.520	210.528	0.493	0.481	4.750	-2.858
$e(t)$	-1436.630	1436.630	-7.112	-7.180	0.000	-8.213	-1462.990	1462.990	-7.243	-7.186	0.000	-11.580	-1489.350	1490.220	-7.373	-7.192	0.327	-15.830
$e(t) - p(t)$	-1218.170	1218.170	-6.031	-6.082	0.000	-7.142	-1241.270	1241.270	-6.145	-6.079	0.000	-10.400	-1264.390	1274.020	-6.259	-6.076	1.882	-14.550
$f(t)$	-413.789	496.562	-2.048	-2.237	7.003	-5.295	383.071	2401.270	1.896	-1.764	61.870	-33.050	1179.910	4596.460	5.841	-1.290	123.800	-62.320
$g(t)$	36.429	36.429	0.180	0.157	2.513	0.000	31.754	31.862	0.157	0.155	0.341	-0.014	27.080	40.468	0.134	0.153	0.516	-2.467
$ig(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$ip(t)$	-0.698	1.243	-0.003	0.000	0.035	-0.168	-1.047	7.823	-0.005	-0.001	0.161	-0.372	-1.395	15.780	-0.007	-0.001	0.380	-0.576
$k^g(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$k^p(t)$	-156.026	156.989	-0.772	-0.784	0.351	-0.935	-150.190	164.261	-0.744	-0.763	0.725	-2.064	-144.351	209.829	-0.715	-0.742	2.357	-3.282
$m(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$m(t) - p(t)$	218.471	218.471	1.082	1.098	1.505	0.000	221.715	221.715	1.098	1.107	1.872	0.000	224.957	224.961	1.114	1.116	2.691	-0.003
$N\sigma^d(t)$	-158.661	159.317	-0.785	-0.785	0.246	-1.308	-159.339	162.059	-0.789	-0.773	0.245	-1.804	-160.017	188.418	-0.792	-0.761	1.423	-2.775
$N\sigma^s(t)$	-157.143	157.143	-0.778	-0.785	0.000	-0.909	-158.771	159.310	-0.786	-0.776	0.072	-1.706	-160.400	177.901	-0.794	-0.767	1.044	-2.581
$\sigma^{ss}(t)$	-43.896	43.896	-0.217	-0.220	0.000	-0.291	-44.296	44.296	-0.219	-0.221	0.000	-0.317	-44.696	44.696	-0.221	-0.222	0.000	-0.422
$p(t)$	-218.471	218.471	-1.082	-1.098	0.000	-1.505	-221.715	221.715	-1.098	-1.107	0.000	-1.872	-224.957	224.961	-1.114	-1.116	0.003	-2.691
$dp/dt$	-0.441	1.078	-0.002	0.000	0.152	-0.365	-0.430	4.472	-0.002	0.001	0.093	-0.251	-0.420	8.567	-0.002	0.001	0.186	-0.529
$q(t)$	-0.997	1.776	-0.005	0.000	0.050	-0.239	-1.495	11.176	-0.007	-0.001	0.230	-0.531	-1.993	22.543	-0.010	-0.002	0.543	-0.823
$r(t)$	1.952	3.151	0.010	0.000	0.665	-0.145	-0.534	22.234	-0.003	-0.005	1.247	-0.622	-3.020	44.207	-0.015	-0.009	1.830	-1.279
$R(t)$	-0.558	2.814	-0.003	0.000	0.040	-0.207	-4.291	24.214	-0.021	-0.006	0.383	-0.620	-8.025	48.702	-0.040	-0.012	0.749	-1.253
$T(t)$	-718.812	718.812	-3.558	-3.590	0.000	-4.155	-731.372	731.372	-3.621	-3.592	0.000	-5.795	-743.930	744.735	-3.683	-3.594	0.280	-7.924
$t^x(t)$	29.988	31.555	0.148	0.156	1.043	-0.138	24.061	78.181	0.119	0.164	1.498	-1.348	18.134	139.223	0.090	0.171	3.111	-2.778
$t^x(t) - g(t)$	-6.441	11.179	-0.032	-0.001	0.454	-1.469	-7.693	75.253	-0.038	0.008	1.509	-1.677	-8.946	152.445	-0.044	0.018	3.986	-3.275
$w(t)$	18.359	22.353	0.091	0.080	0.562	-0.994	25.024	89.476	0.124	0.070	2.036	-1.708	31.690	172.118	0.157	0.060	3.905	-3.907
$w(t) - p(t)$	236.830	236.830	1.172	1.178	1.632	0.000	246.737	248.845	1.221	1.177	3.029	-0.301	256.646	289.570	1.271	1.176	4.807	-2.235
$w^p(t)$	2033.840	2046.350	10.069	10.560	11.050	-2.239	2156.120	2177.030	10.674	10.750	27.740	-2.531	2278.410	2627.970	11.279	10.950	45.680	-12.250
$y(t)$	219.459	219.459	1.086	1.098	1.452	0.000	221.459	221.459	1.096	1.105	1.585	0.000	223.460	223.460	1.106	1.112	2.109	0.000
$y^p(t)$	345.170	345.170	1.709	1.726	1.878	0.000	348.473	348.473	1.725	1.726	2.343	0.000	351.776	351.776	1.741	1.725	2.936	0.000

**Table 8 Scenario profiles**

Period $n$		1	2	3	4	5	6 – 200
Shock		$pres$	0	10%	10%	10%	10%
Response	— — — — — $(+) k^{g*}$		0	0	2.5%	5%	2.5%
	————— $(0) k^{g*}$		0	0	0	0	0
	• • • • • $(-) k^{g*}$		0	0	–2.5%	–5%	–2.5%

Outcomes from each of these three scenarios for selected macroeconomic variables can be observed from Figure 2 and from Table 9. As for the previous case, analysis of the macroeconomic adjustment process is confined to that of the real exchange rate, private capital stock, non-resource demand and supply, the  $q$  ratio, interest rate and return on real physical assets, the non-resource trade balance and real income. It can be observed from Figure 2 that all the key macroeconomic variables are subject to volatility during the period of adjustment. Adjustment by key macroeconomic variable is now briefly discussed.

In the short to medium term there is a sizeable appreciation of the real exchange rate for the baseline scenario and for the transient increase and decrease in government capital spending scenarios. It can be observed from Figure 2 that the exchange rate, both nominal and real, is noticeably more volatile in the transient increase in government capital spending scenario (scenario 2) relative to the transient increase in government consumption spending scenario, while the opposite is true for the transient decrease in government capital expenditure scenario relative to the government transient decrease in consumption spending. These real exchange rate appreciations result in a loss of competitiveness for non-resource exports, and, as can be observed from Figure 2, are again driven primarily by an appreciation of the nominal exchange rate. Table 9 enables identification of the long run appreciation of the exchange rate and the extent of volatility over the entire adjustment process. Over the long-run the appreciation of the real exchange rate in all three scenarios is about 7.2 per cent, as for the first case. The real exchange rate is most volatile for the case of a transient increase in government capital spending and least volatile for the case of a transient decrease in government capital spending. If we compare these results with that for the transient change in government consumption spending (Table 7), we notice that an **increase** in government consumption spending reduces the extent of real exchange rate volatility while this can similarly be achieved by **reducing** government capital spending. **Consequently, reducing government capital expenditure can reduce the size of real and nominal exchange rate volatility in response to a resource price shock relative to the baseline scenario. It can also be observed from Table 9 that the appreciation of the real exchange rate, on average, throughout the adjustment process can be reduced by reducing government capital expenditure.**

The private capital stock is also subject to volatility in all three scenarios, but again this is most apparent in the case of scenario 2 (see Figure 2 and Table 9), where government capital expenditure is increased. Volatility in the private capital stock can be reduced by reducing government capital expenditure. While the private capital stock is reduced under all three scenarios, by around 0.75 per cent in steady state, the lowest average decline throughout the simulation period occurs in scenario 2. While the least volatile scenario for this variable is scenario 3, where there is a decrease in government capital spending, this is offset by the greater average percentage decline for this variable throughout the simulation period. The government again faces a tough decision with respect to this variable. Its volatility can be reduced through a reduction in government capital spending but the average decline in this variable throughout the adjustment process is larger. **Consequently, the government can reduce the volatility of adjustment of the private capital stock arising from a positive resource price shock by either increasing government consumption spending or reducing government capital spending. However, the average decline in this variable throughout the adjustment process is least where government capital**

**spending is increased or government consumption spending is reduced.** This again suggests that implementation of an appropriate policy can improve key variable macroeconomic outcomes.

Non-resource demand and supply are also subject to major volatility, and both of these key variables are lower in the long run steady state for all scenarios by around 0.78 per cent. Most volatility occurs in scenario 2 while the lowest volatility, interestingly, occurs in the baseline case. The primary reason for the overall deterioration in non-resource demand is due to the overall deterioration in the non-resource trade balance for all three scenarios, which is strongly linked to the appreciation of the real exchange rate mentioned previously. Private investment expenditure also remains largely stagnant, while overall government expenditure increases slightly and private consumption spending more so. As for the previous case the severe external developments exert major downward pressure on non-resource demand. The deterioration in non-resource supply is driven by higher real wages, a lower private capital stock and flat public capital expenditure. In the case of transient changes in government capital expenditure, an increase produces greater volatility in the adjustment of both non-resource demand and supply but the lowest average percentage decline in these variables throughout the adjustment process. A reduction in government capital spending decreases the volatility of adjustment of these two variables relative to the increase in government capital spending case, but increases this relative to the baseline scenario. The decreased government capital spending scenario results in a larger average percentage decline in the variable during the adjustment process. **Consequently the authorities face an important trade off if such policy responses are used. Increasing capital spending will reduce the average decline of the variable, relative to baseline, but increase its volatility of adjustment, while a decrease in capital spending will also increase its volatility of adjustment as well as the average decline in the variable relative to baseline.**

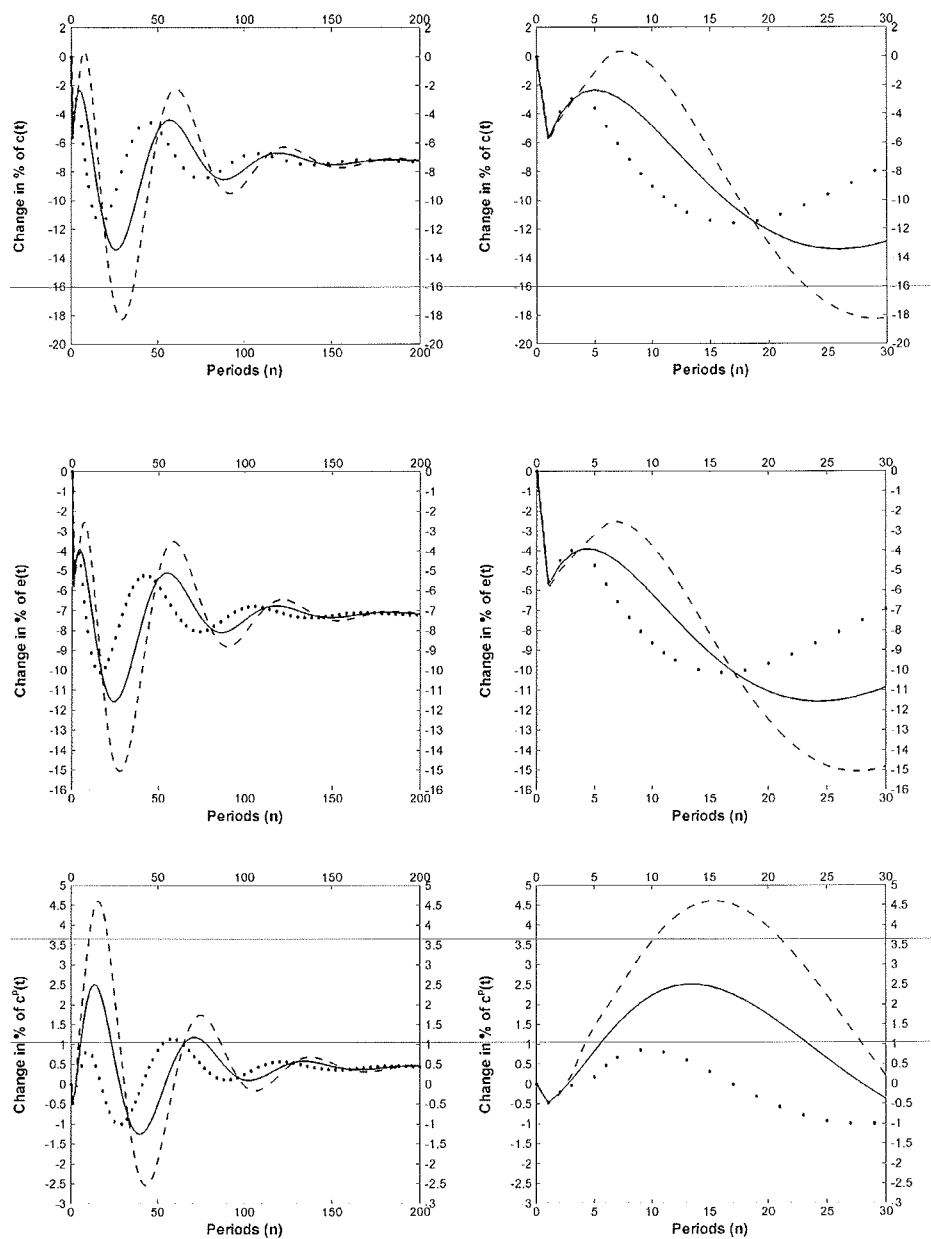
In terms of adjustment of the major financial variables, some interesting adjustment processes can be observed from Figure 2 and Table 9. Volatility of adjustment of the  $q$  ratio is increased where government capital expenditure is increased and decreased where government capital expenditure is decreased relative to baseline. There is very little difference between them in terms of the average change in the variable during the adjustment process, which is below the base level. Overall volatility outcomes for this variable could, therefore, be improved through a decline in government capital spending in response to a positive resource price shock. However, this policy will produce the largest average percentage declines in these variables throughout the adjustment process. For the interest rate its volatility of adjustment can be improved by reducing government capital expenditure, and will result in a lower average rate during the adjustment process. The reverse is the case for an increase in government capital expenditure. From the perspective of the interest rate a policy of reducing government capital spending could improve performance relative to that of the baseline performance. In terms of returns on real capital assets, a policy response of reducing government capital expenditure would reduce its volatility of adjustment but result in a lower return on physical assets on average throughout the adjustment process. **A policy response of increasing government capital spending would increase the volatility of adjustment of this variable but result in a lower decline on average on the returns to physical capital.**

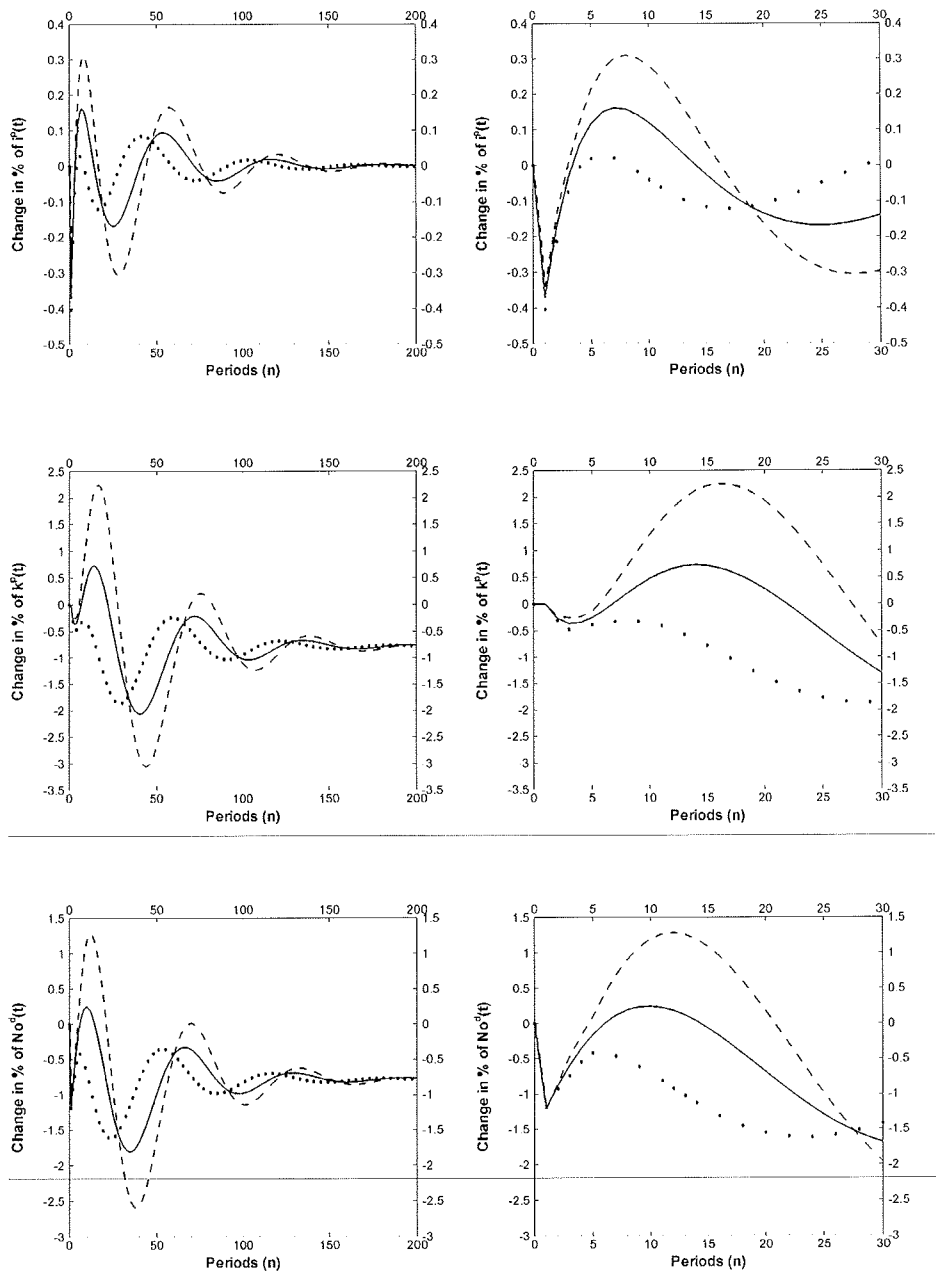
In terms of the non-resource trade balance, it can be observed that, while this variable is also subject to volatility during the adjustment process, such volatility can be improved by reducing government capital expenditure as well as reducing the average percentage decline in this variable during the adjustment process. **For the non-resource trade balance a policy response emphasising a reduction in government capital spending can unambiguously improve upon outcomes relative to the baseline scenario.**

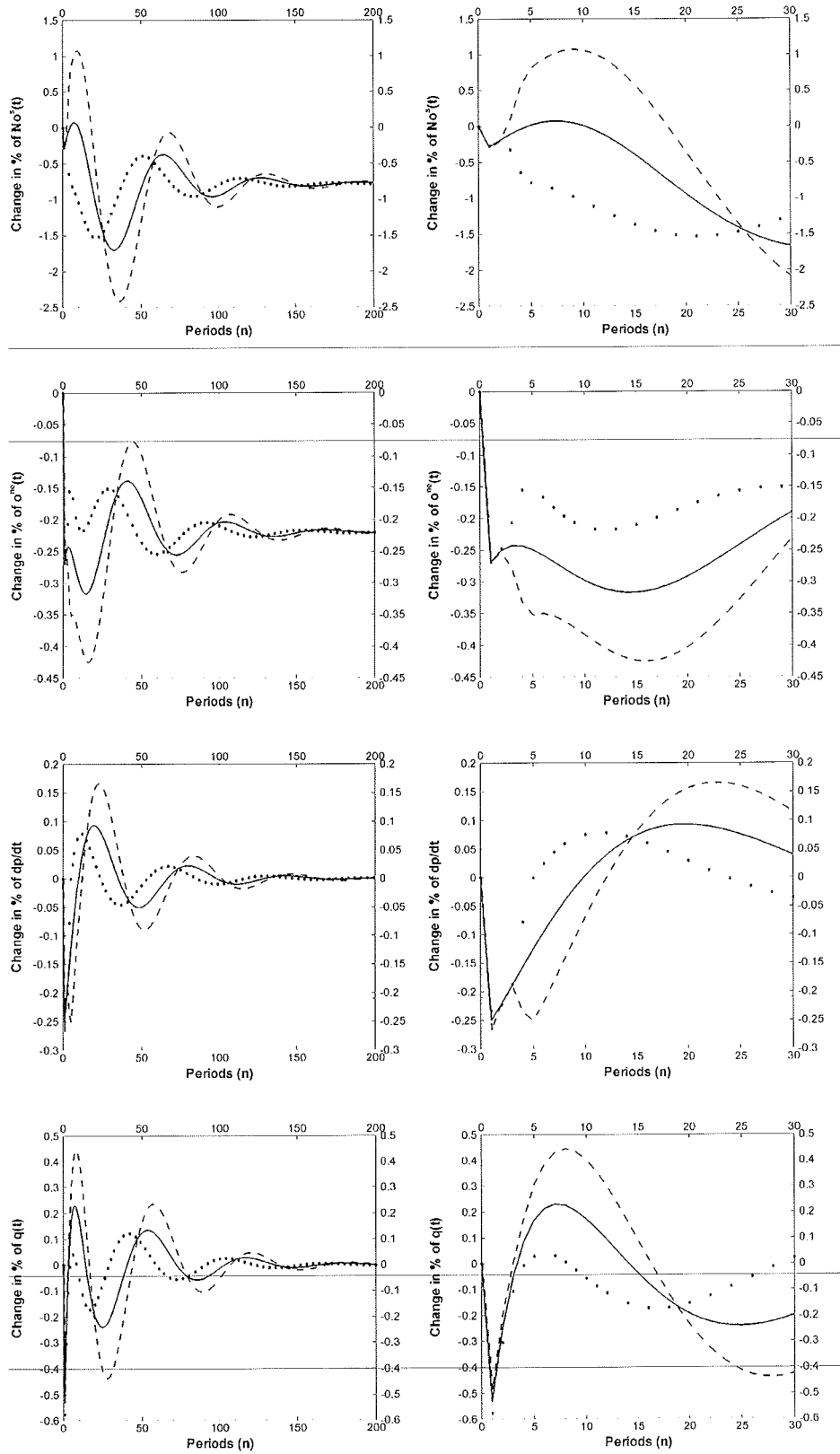
Finally, developments in real income are also quite illuminating for all three scenarios. Volatility is noticeably larger in scenario 2 and lower in scenario 3. The baseline case is in the middle. Hence a **policy response can be justified if the objective is to reduce the volatility of adjustment of this**

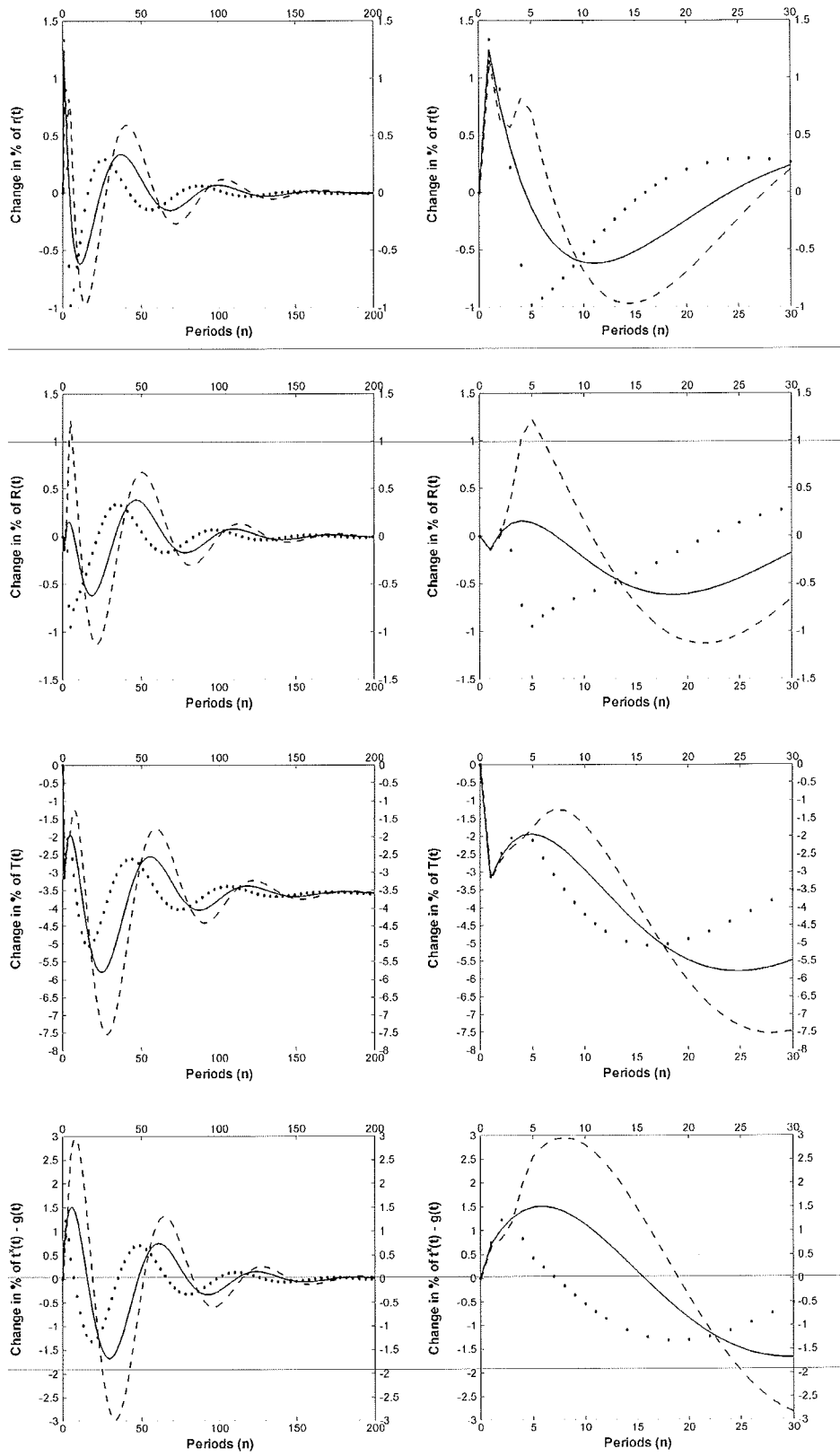


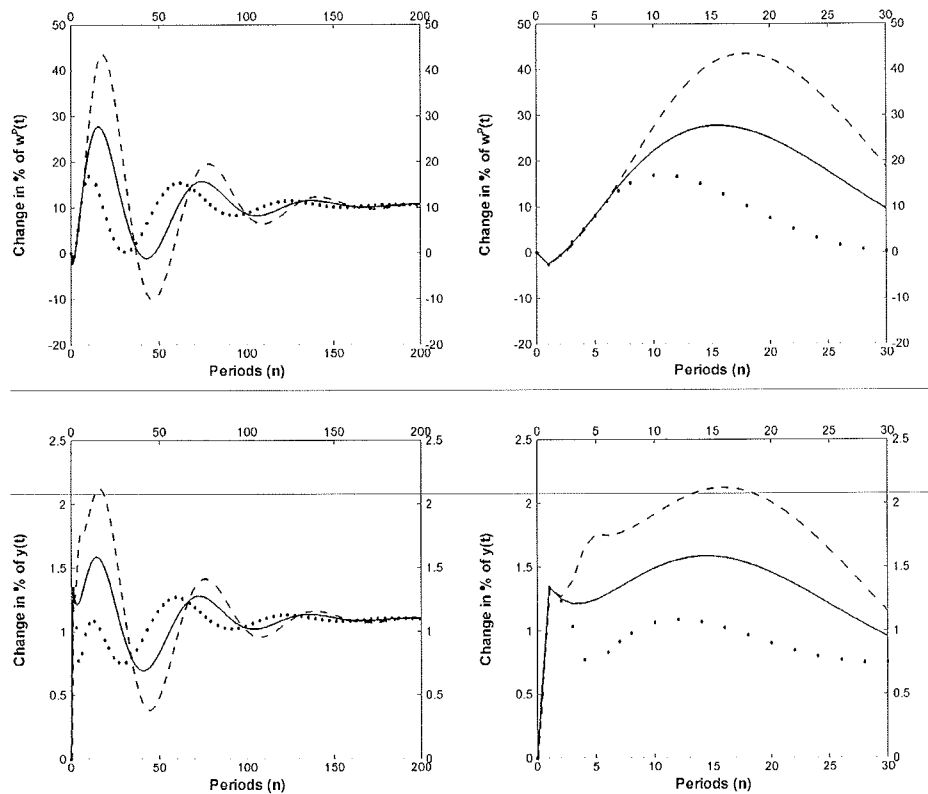
**Figure 2 Macroeconomic adjustment from a permanent and instantaneous 10 per cent increase in the price of the resource, and transient increases/decreases in government capital spending**











variable. The preferred case, this being so, is a reduction in government capital expenditure. On the other hand such a policy response produces the lowest average percentage increase in this variable throughout the adjustment process. In this regard an increase in government capital expenditure is preferred.

We can conclude from the simulation results presented in Figure 2 and Table 9 that outcomes for the resource exporter can be improved, as measured by key macroeconomic variable adjustment volatility and/or its average percentage performance during the adjustment process from baseline outcomes, through a judicious policy response. The results presented suggest, however, that there are few instances where both variability and average percentage outcomes for a key macroeconomic variable can be improved through the adoption of a single policy.

Baseline performance can be improved from a positive resource price shock in terms of volatility of adjustment using reduced government capital spending for the real exchange rate, private sector capital stock,  $q$  ratio, the interest rate, real capital stock returns and real income. For none of the key macroeconomic variables does an increase in government capital stock reduce volatility of adjustment. However, an improved average percentage adjustment performance from an increase in government capital spending can be achieved for the private capital stock, non oil demand and supply, real returns on physical assets, and real income. A cut in government consumption spending produces a better average performance than baseline for the real exchange rate, the interest rate and the non-resource trade balance.

## 5. Conclusions and discussion

It can be reasonably expected that in a world where there is insatiable demand for resources that the price of such resource must rise over the long term. In this environment it is important for major resource producing and exporting countries to have a clear understanding of the macroeconomic implications arising from higher resource prices. The dynamic macroeconomic model presented in this paper has demonstrated the potential to analyse, in a substantive way, the macroeconomic implications arising for a resource producing and exporting economy from a resource price hike, and possible policy responses to improve macroeconomic outcomes. Focus in this paper was placed entirely upon transient government consumption and capital expenditure changes. Other policy responses can be considered in the context of this framework, such as monetary and tax changes. This can be conducted in subsequent studies.

The major conclusions to be drawn from the paper are that a permanent resource price hike has the potential to sustain an increase in private sector wealth and real income, and, temporarily at least, improve the current account. However, the resource price boom has the potential to reduce non resource demand and supply, deteriorate the non resource trade balance through a loss of competitiveness from a real exchange rate appreciation. It was also observed that such a resource disturbance has the potential to generate considerable instability in financial markets. The loss of non resource output could be of considerable importance in terms of its employment consequences, and the potentially adverse effect on capital stock in the non resource sector detrimental not only to employment generation but also to the longer term growth of the economy and to the non-resource sector specifically. The model, therefore, does suggest the existence of a Dutch disease effect from a resources boom.

Policy responses focusing upon government consumption and capital expenditure have the potential to improve macroeconomic outcomes for key variables, although a conflict can arise between reducing volatility and the average percentage change of that variable during the adjustment process. There are few cases where both volatility and average percentage change can both be improved for a variable from a single policy. In most instances the government faces the difficult task of prioritising macroeconomic variable outcomes (for example real output or the trade balance), volatility reduction or better average percentage performance from base value for that variable. More research is required to further clarify these issues.

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